Scour Evaluation and Countermeasure Design

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Scour

- To remove dirt and debris from a pipe or ditch
- To clear, dig, or remove by or as if by a powerful current of water.
- Is the result of the erosive action of flowing water, excavating and carrying away material from the bed and banks of streams.

Evaluation of Scour

Field Scour

Scour by calculation

Field Scour Assessment

- Visible Scour (scour area apparent)
  1. Undermining of abutment wall
  2. Exposed pier/bent piles

- Non-visible (scour area non-apparent)
  1. Manual or electronic probing the soil at the abutment wall and the base of piers and bents

Manual probing

- Measures scour depths
- Measurements limited to length of probe

Electronic probing

- Electronic probes (by USGS)
- Measures greater depths than manual probe

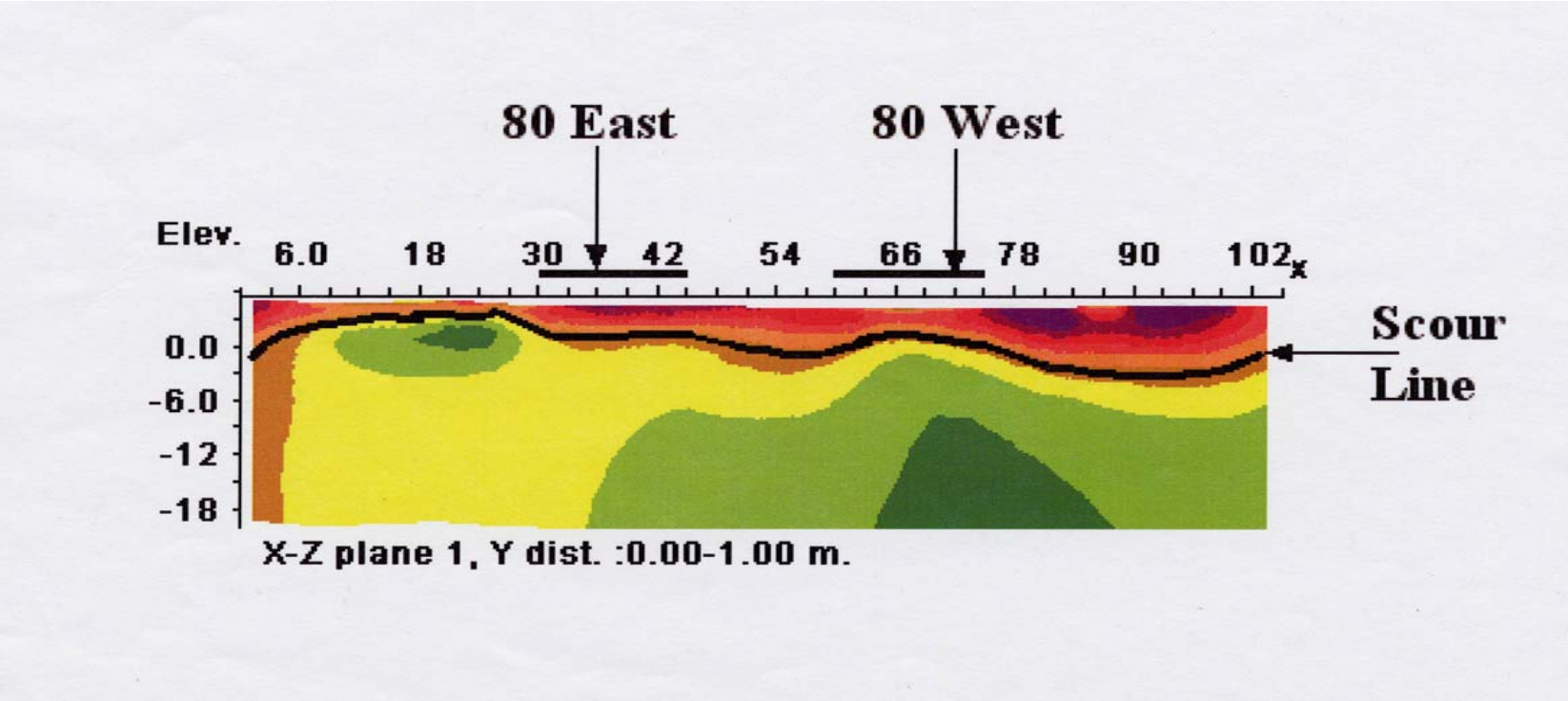
Electronic Resistivity Meter

- Measures soil depths of different densities

Electronic Probe layout

- Obtaining density readings at constant intervals.

Electronic scour output



- Color graph showing depths of scour along the channel.

Scour by calculation

Evaluation by calculation

1. Live-Bed Contraction Scour (HEC-RAS)

$Y_2/Y_1=(Q_2/Q_1)^{6/7} * (W_1/W_2)^{k1}$

2. Local pier Scour (HEC-RAS)

$Y_S/a = 2.0\ K_1\ K_2\ K_3\ K_4\ (Y_1/a)^{0.35}\ Fr^{0.43}$

Calculation by velocity assessment

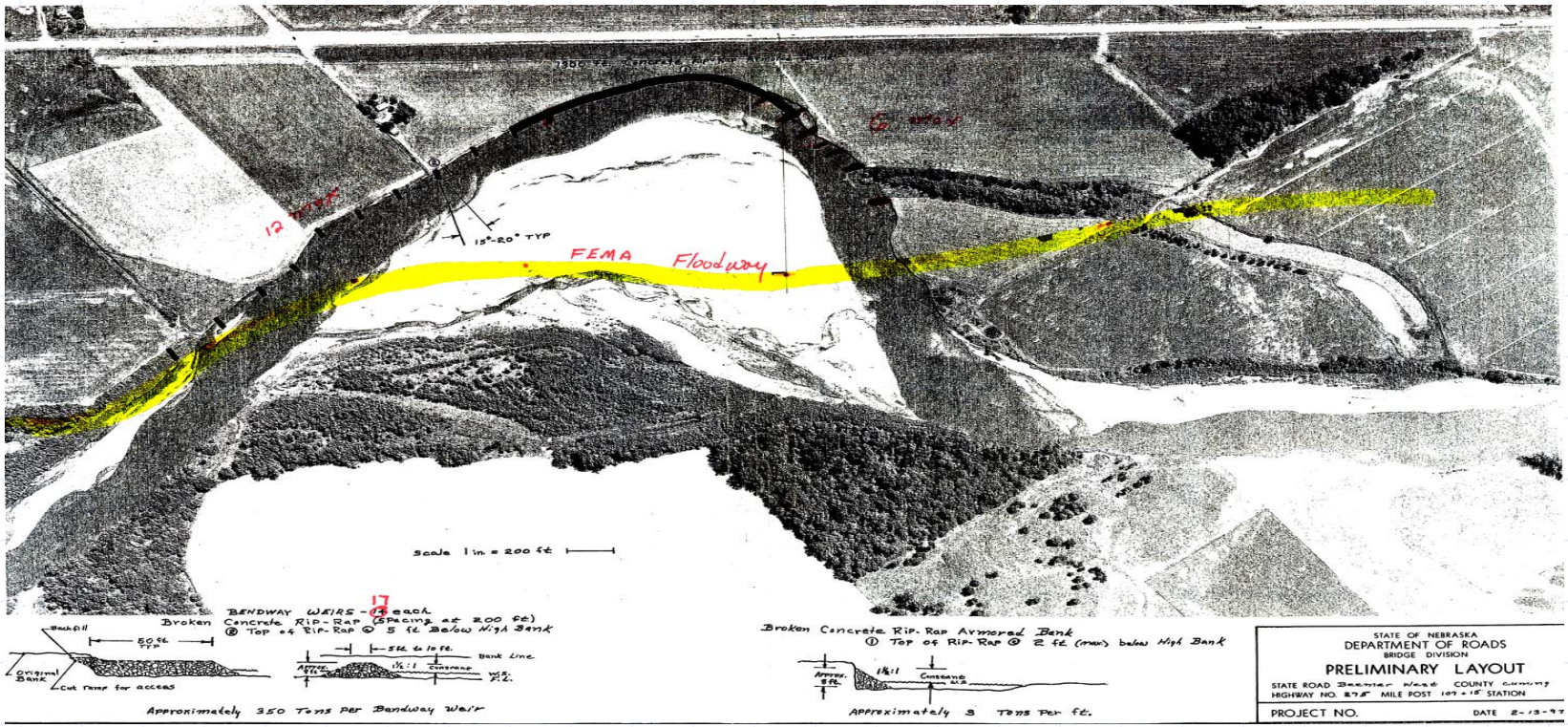
1. $(Q=V_{scour}\ A_{scour})$

   1 mm D_{50} Sand ≙ 5 ft/s ; Clay ≙ 7 ft/s

Scour Countermeasure Design

1. Meandering channel
2. Degrading channel
3. Channel headcuts
4. Abutment scour
5. Bridge failure

Example of active meandering



- Elkhorn River was cutting North through a corn field to Hwy. 275.

Impacts of active meandering

- Unstable banks
- Loss of farmland
- State highway in jeopardy
- Meandered an average of 50’ per month

Countermeasure for Meandering

- Placed Bendway Weirs and broken concrete
- Thalweg shifts away from bank
- Reduces velocity at the toe of the bank

Results of countermeasure

- Vegetation re-established along the bank line

Example of degradation and local scour

- Little Nemaha River
- Channel degraded
- Pier piles were exposed
- Local pier scour
- Structure integrity

Countermeasure for exposed pier footing

- Sloped the sides at a 2H:1V.
- Rip-rapped around the pier footings and slopes up to the berm.

Example of a Headcut

- Logan Creek
- Downstream of bridge site
- 5’ headcut
- Due to straightening of the channel downstream.

Headcut countermeasure

- Drove sheet pile in the channel, along the wings and up the slopes to stop the headcut and protect the substructure.
- Poured concrete slope protection on a 2H:1V slope up to the berm.

Example of a ditch headcut

- Degraded Plum Creek Tributary
- Bridge was stable
- Degradation advancing up the road ditch

Ditch headcut countermeasure

- Gabion Drop structure installed
- 75’ long with a 7.5’ drop in elevation

Example of abutment scour

- Concrete wall abutment
- Undermining abutment wall
- Approach failure imminent

Abutment scour countermeasure

- Drove sheet pile around abutment and filled in with concrete.
- Placed broken concrete around abutment.

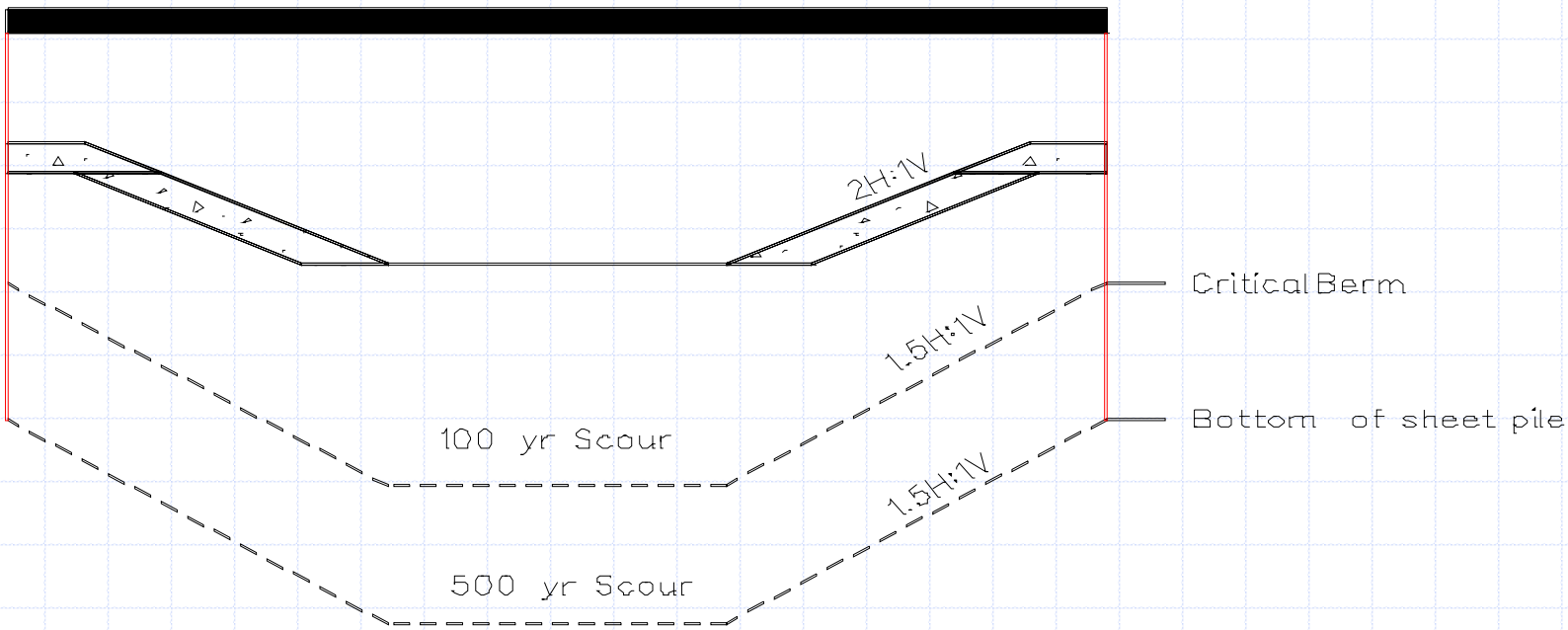
Example of abutment scour

- Undermining abutment
- Exposed piling

Abutment scour countermeasure

- Poured 8’ retaining wall underneath bridge
- Drove steel sheet pile on the sides
- Broken concrete riprap

New countermeasure sheet pile wall abutment design



- Q_{100} scour critical berm
- Q_{500} scour bottom of sheet pile

Example of a bridge failure

- South Fork Big Nemaha
- Active meandering channel
- Flood of 1993

Arial view

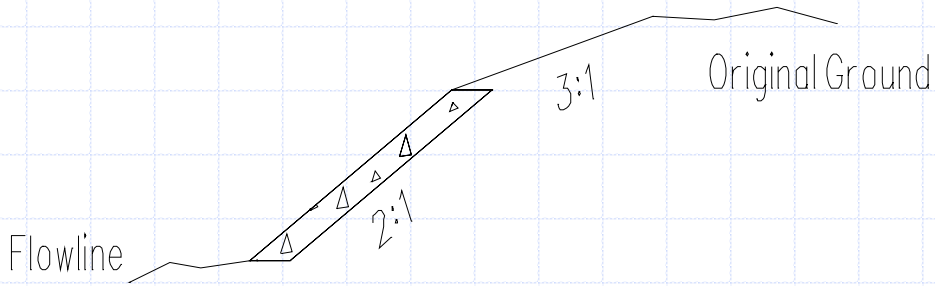
- Meander cut-off

Bridge failure

- Tree debris on East abutment routed flow toward West abutment, washing it out.

East side channel stabilization

- Sloped and rip-rapped 2H:1V up to the annual flow elevation and then sloped 3H:1V

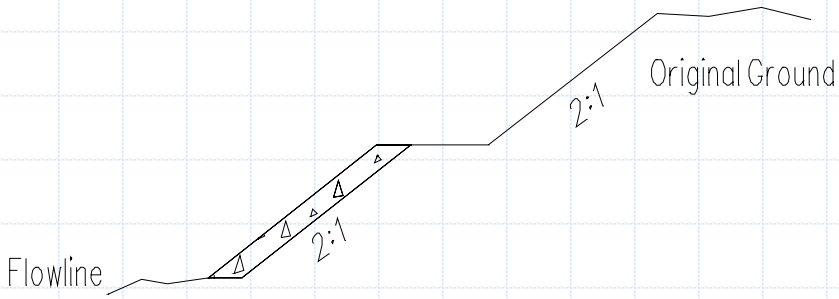


Stabilized channel

- Vegetation has filled in on both slopes
- Stable banks

West side channel stabilization

- Two tier design
- 2:1 slope
- 15’ berm at annual flow



Stabilization channel

- Vegetation has filled in
- Stable banks

Questions?